

WHAT IS CLAIMED IS:

1                   1.       A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3                   providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position, the obstruction removing element having a wire which has a  
5 distal end coupled to an insertion element, the wire also having a proximal end which is slidable  
6 on the insertion element;

7                   positioning the obstruction removing element in a catheter with the obstruction  
8 removing element in the collapsed position;

9                   advancing the catheter through the obstruction;

10                  moving the obstruction engaging element out of the catheter after the advancing  
11 step so that the obstruction removing element moves toward the expanded position; and

12                  engaging the obstruction by moving the obstruction engaging element after the  
13 advancing step.

14                  2.       The method of claim 1, wherein:

15                  the providing step is carried out with a stop coupled to the insertion element, the  
16 stop preventing distal advancement of the proximal end.

17                  3.       The method of claim 1, wherein:

18                  the advancing step is carried out with the obstruction removing element wrapped  
19 around the insertion element during the advancing step.

20                  4.       An obstruction removing device, comprising:

21                  an obstruction removing element which is movable from a collapsed position to  
22 an expanded position, the obstruction removing element having a wire which has a distal end  
23 coupled to an insertion element, the wire also having a proximal end which is slidable on the  
24 insertion element.

25                  5.       The device of claim 4, wherein:

26                  the insertion element has a stop, the stop preventing distal advancement of the  
27 proximal end of the wire.

1           6.     The device of claim 4, wherein:

2           the obstruction removing element is wrapped around the insertion element.

1           7.     A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3           providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position;

5           positioning the obstruction removing element in a catheter with the obstruction  
6 removing element in the collapsed position;

7           advancing the catheter through the obstruction;

8           moving a distal end of the obstruction engaging element out of the catheter after  
9 the advancing step so that the obstruction removing element expands distal to the obstruction,  
10 wherein at least part of the obstruction engaging element proximal to the distal end expands  
11 within the obstruction; and

12           removing the obstruction by moving the obstruction engaging element after the  
13 advancing step.

14           8.     The method of claim 7, wherein:

15           the moving step is carried out with a proximal end of the obstruction engaging  
16 element expanding on a side of the obstruction opposite the distal end so that the obstruction is  
17 trapped between the expanded proximal and distal ends.

18           9.     The method of claim 7, wherein:

19           the providing step is carried out with the obstruction removing element having  
20 coils, wherein the obstruction engaging element has a distal portion and a proximal portion, the  
21 distal and proximal portion having coils larger than an intermediate section between the distal  
22 and proximal portions.

23           10.    The method of claim 7, wherein:

24           the providing step is carried out with the obstruction removing element having a  
25 distal portion and a proximal portion, the proximal portion having coils which wind distally, then  
26 wind proximally and then distally again toward the distal portion.

1 11. The method of claim 10, wherein:  
2 the moving step is carried out with the proximal portion expanding on a side of  
3 the obstruction opposite the distal end of the obstruction removing element.

1 12. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:  
3 providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position, the obstruction removing element being covered with a cover;  
5 positioning the obstruction removing element in a catheter with the obstruction  
6 removing element in the collapsed position;  
7 advancing the catheter through the obstruction;  
8 moving the obstruction engaging element out of the catheter after the advancing  
9 step so that the obstruction removing element moves toward the expanded position; and  
10 engaging the obstruction by moving the obstruction engaging element after the  
11 advancing step.

1 13. The method of claim 12, wherein:  
2 the providing step is carried out with the cover being a braided structure.

1 14. The method of claim 13, wherein:  
2 the providing step is carried out with the braided structure loosely covering the  
3 obstruction removing element.

1 15. The method of claim 13, wherein:  
2 the providing step is carried out with the braided structure loosely covering the  
3 obstruction removing element and providing substantially no structural characteristics to the  
4 obstruction removing element.

1 16. The method of claim 12, wherein:  
2 the providing step is carried out with the cover being a flexible tube or ribbon.

1 17. The method of claim 16, wherein:

2 the providing step is carried out with the flexible tube being a PTFE tube or  
3 ribbon.

1 18. The method of claim 16, wherein:  
2 the providing step is carried out with the flexible tube being expanded PTFE.

1 19. The method of claim 12, wherein:  
2 the providing step is carried out with the cover providing substantially no  
3 structural properties to the device so that the cover essentially follows the shape of the device.

1 20. The method of claim 12, wherein:  
2 the moving step is carried out with the cover forming creased sections which  
3 enhance engagement with the obstruction when the device expands toward the expanded  
4 position.

1 21. A device for removing an obstruction from a blood vessel, comprising:  
2 a delivery catheter;  
3 an obstruction removing element which is movable from a collapsed position to  
4 an expanded position, the obstruction removing element being covered with a cover, the delivery  
5 catheter holding the obstruction removing element in the collapsed position.

1 22. The device of claim 21, wherein:  
2 the cover is a braided structure.

1 23. The device of claim 22, wherein:  
2 the braided structure loosely covers the obstruction removing element.

1 24. The device of claim 22, wherein:  
2 the braided structure loosely covers the obstruction removing element and  
3 provides substantially no structural characteristics to the obstruction removing element.

1 25. The device of claim 21, wherein:  
2 the cover is a flexible tube.

1 26. The device of claim 25, wherein:

2 the flexible tube comprises PTFE.

1 27. The device of claim 25, wherein:

2 the flexible tube is expanded PTFE.

1 28. The device of claim 21, wherein:

2 the cover provides substantially no structural properties to the element so that the  
3 cover essentially follows the shape of the element.

1 29. The device of claim 21, wherein:

2 the cover forms creased sections which enhance engagement with the obstruction  
3 when the element expands toward the expanded position.

1 30. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3 providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position, the obstruction removing element having a first elongate  
5 element and a second elongate element, the first and second elongate elements extending  
6 substantially parallel to one another when in the collapsed and expanded positions;

7 positioning the obstruction removing element in a catheter with the obstruction  
8 removing element in the collapsed position;

9 advancing the catheter through the obstruction;

10 moving the obstruction engaging element out of the catheter after the advancing  
11 step so that the obstruction removing element moves toward the expanded position; and

12 engaging the obstruction by moving the obstruction engaging element after the  
13 advancing step.

1 31. The method of claim 30, wherein:

2 the providing step is carried out with the first elongate element being stiffer than  
3 the second elongate element.



2 the first elongate element being a round coil and the second elongate element is  
3 ribbon coil.

1 40. The device of claim 37, wherein:  
2 the second elongate element having proximal and distal ends both connected to  
3 the first elongate element.

1 41. The device of claim 40, wherein:  
2 the second elongate element being suture.

1 42. The device of claim 37, wherein:  
2 the first and second elongate elements form coils when in the expanded position.

1 43. The device of claim 37, wherein:  
2 the first elongate element being wrapped around the second elongate element to  
3 form an insertion element, wherein the insertion element does not expand when the obstruction  
4 removing element moves to the expanded position.

1 44. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3 providing an obstruction removing device having a first obstruction removing  
4 element and a second obstruction removing element, the first and second obstruction removing  
5 elements both being movable from a collapsed position to an expanded position, the first and  
6 second obstruction removing elements being independently movable;

7 positioning the obstruction removing device in at least one catheter with the first  
8 and second obstruction removing elements in the collapsed position;

9 advancing the catheter through the obstruction;

10 moving the first obstruction engaging element out of the catheter after the  
11 advancing step so that the obstruction removing element moves toward the expanded position;

12 expanding the second obstruction engaging element on an opposite side of the  
13 obstruction from the first obstruction engaging element so that the obstruction is positioned  
14 between the first and second obstruction engaging elements; and

15 engaging the obstruction by moving at least one of the first and second obstruction  
16 engaging elements.

1 45. The method of claim 44, wherein:  
2 the providing step is carried out with the first and second obstruction engaging  
3 elements both being elongate elements which each extend to a free end.

1 46. A device for removing an obstruction from a blood vessel, comprising the  
2 steps of:  
3 an obstruction removing device having a first obstruction removing element and a  
4 second obstruction removing element, the first and second obstruction removing elements both  
5 being movable from a collapsed position to an expanded position, the first and second  
6 obstruction removing elements being independently movable.

1 47. The device of claim 46, wherein:  
2 the first and second obstruction engaging elements are both being elongate  
3 elements which each extend to a free end.

1 48. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:  
3 providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position, the obstruction removing element having at least two struts  
5 extending from an elongate insertion element, the obstruction removing element also having at  
6 least two arms extending from a distal end of each of the struts;  
7 positioning the obstruction removing element in a catheter with the obstruction  
8 removing element in the collapsed position;  
9 advancing the catheter through the obstruction;  
10 moving the obstruction engaging element out of the catheter after the advancing  
11 step so that the obstruction removing element moves toward the expanded position, wherein at  
12 least a distal end of the obstruction engaging element is positioned distal to the obstruction; and  
13 engaging the obstruction by moving the obstruction engaging element after the  
14 advancing step.



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1 49. The method of claim 48, wherein:  
2 the providing step is carried out with the obstruction removing element having  
3 two struts.

1 50. The method of claim 48, wherein:  
2 the providing step is carried out with the obstruction removing element having  
3 three struts.

1 51. The method of claim 48, wherein:  
2 the providing step is carried out with the struts have a length of less than 1/3 a  
3 length of the arms.

1 52. The method of claim 48, wherein:  
2 the providing step is carried out with a proximal end of the struts extending from a  
3 distal end of the insertion element and the proximal end of the arms extending from a distal end  
4 of the struts.

1 53. The method of claim 52, wherein:  
2 the providing step is carried out with a distal end of the arms being coupled  
3 together to form a tip of a cage-like structure formed by the struts and arms.

1 54. A device for removing an obstruction from a blood vessel, comprising the  
2 steps of:  
3 an obstruction removing element which is movable from a collapsed position to  
4 an expanded position, the obstruction removing element having at least two struts extending  
5 from an elongate insertion element, the obstruction removing element also having at least two  
6 arms extending from a distal end of each of the struts.

1 55. The device of claim 54, wherein:  
2 the obstruction removing element has two struts.

1 56. The device of claim 54, wherein:  
2 the obstruction removing element having three struts.

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1 57. The device of claim 54, wherein:

2 the struts has a length of less than  $\frac{1}{3}$  a length of the arms.

1 58. The device of claim 54, wherein:

2 the struts have a proximal end which extend from a distal end of the insertion  
3 element and the arms have a proximal end which is coupled to the distal end of the struts.

1 59. The device of claim 58, wherein:

2 the arms each have a distal end which come together to form a tip of a cage-like  
3 structure formed by the struts and arms.

1 60. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3 providing an obstruction removing element which is movable from a collapsed  
4 position to an expanded position, the obstruction removing element having a first elongate  
5 element, a second elongate element, and a third elongate element, the first, second and third  
6 elongate elements extending independently of one another and each having a proximal and distal  
7 end, the first, second and third elongate elements forming a cage-like structure between their  
8 proximal and distal ends when in the expanded position;

9 positioning the obstruction removing element in a catheter with the obstruction  
10 removing element in the collapsed position;

11 advancing the catheter through the obstruction;

12 moving the obstruction engaging element out of the catheter after the advancing  
13 step so that the obstruction removing element moves toward the expanded position; and

14 engaging the obstruction by moving the obstruction engaging element after the  
15 advancing step.

1 61. The method of 60, wherein:

2 the providing step is carried out with the first, second and third elongate elements  
3 forming coils, wherein the first, second and third elongate elements form 1-5 coils relative to a  
4 longitudinal axis of the obstruction removing element when expanded.

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1           62.     The method of claim 60, wherein:  
2           the providing step is carried out with the first, second and third elongate elements  
3 forming coils, wherein the coils are wound in the same direction.

1           63.     The method of claim 60, wherein:  
2           the providing step is carried out with the first, second and third elongate elements  
3 being positioned asymmetrically when viewed from an end so that the obstruction may enter a  
4 larger opening between the first, second and third elongate elements.

1           64.     The method of claim 60, wherein:  
2           the providing step is carried out with the first, second and third elongate elements  
3 not being braided or woven and not having interconnecting elements.

1           65.     A device for removing an obstruction from a blood vessel, comprising:  
2           an obstruction removing element which is movable from a collapsed position to  
3 an expanded position, the obstruction removing element having a first elongate element, a second  
4 elongate element, and a third elongate element, the first, second and third elongate elements  
5 extending independently of one another and each having a proximal and distal end, the first,  
6 second and third elongate elements forming a cage-like structure between their proximal and  
7 distal ends when in the expanded position.

1           66.     The device of 65, wherein:  
2           the providing step is carried out with the first, second and third elongate elements  
3 forming coils, wherein the first, second and third elongate elements form 1-5 coils relative to a  
4 longitudinal axis of the obstruction removing element when expanded.

1           67.     The device of claim 65, wherein:  
2           the providing step is carried out with the first, second and third elongate elements  
3 forming coils, wherein the coils are wound in the same direction.

1           68.     The device of claim 65, wherein:

the providing step is carried out with the first, second and third elongate elements being positioned asymmetrically when viewed from an end so that the obstruction may enter a larger opening between the first, second and third elongate elements.

69. The device of claim 65, wherein:  
the providing step is carried out with the first, second and third elongate elements not being braided or woven and not having interconnecting elements.

70. A method of removing an obstruction from a blood vessel, comprising the steps of:

providing an obstruction removing element which is movable from a collapsed position to an expanded position, the obstruction removing element having a wire which extends to a free end, the obstruction removing element forming a number of discrete structures;

positioning the obstruction removing element in a catheter with the obstruction removing element in the collapsed position;

advancing the catheter through the obstruction;

moving the obstruction engaging element out of the catheter after the advancing step so that the obstruction removing element moves toward the expanded position; and

engaging the obstruction by moving the obstruction engaging element after the advancing step.

71. The method of claim 70, wherein:  
the providing step is carried out with a plurality of discrete structures formed by the wire.

72. The method of claim 71, wherein:  
the providing step is carried out with the plurality of discrete structures being substantially parallel to one another when in the expanded position, the plurality of discrete structures all being formed by a continuous length of the wire.

73. The method of claim 71, wherein:  
the providing step is carried out with the plurality of discrete structures having a flower-pedal shape.

1 74. The method of claim 71, wherein:  
2 the providing step is carried out with the plurality of discrete structures having a  
3 similar shape.

1 75. The method of claim 71, wherein:  
2 the providing step is carried out with the plurality of discrete structures being  
3 rotated with respect to one another when viewed along a longitudinal axis of the wire to provide  
4 an interfering pattern.

1 76. A device for removing an obstruction from a blood vessel, comprising:  
2 a delivery catheter;  
3 an obstruction removing element contained within the delivery catheter, the  
4 element being movable from a collapsed position to an expanded position, the obstruction  
5 removing element having a wire which extends to a free end, the obstruction removing element  
6 forming a plurality of discrete structures when in the expanded position, the delivery catheter  
7 holding the element in the collapsed position.

1 77. The device of claim 76, wherein:  
2 the plurality of discrete structures are substantially parallel to one another when in  
3 the expanded position, the plurality of discrete structures all being formed by a continuous length  
4 of the wire.

1 78. The device of claim 76, wherein:  
2 the plurality of discrete structures each have a flower-pedal shape.

1 79. The device of claim 76, wherein:  
2 the plurality of discrete structures each have a similar shape.

1 80. The device of claim 76, wherein:  
2 the plurality of discrete structures are rotated with respect to one another when  
3 viewed along a longitudinal axis of the wire to provide an interfering pattern.

1 81. A method of removing an obstruction from a blood vessel comprising the  
2 steps of:

3 providing an obstruction removing device having a loop and a basket coupled to  
4 the loop, the loop being movable from a collapsed position to an expanded position, the  
5 obstruction removing device having a longitudinal axis, the loop generally lying in a plane which  
6 forms an angle of about 0-25 degrees relative to the longitudinal axis when in the collapsed  
7 position and about 45-135 degrees when in the expanded position;

8 advancing the device through an obstruction;

9 moving the loop to the expanded position; and

10 engaging the obstruction by moving the obstruction removing device.

1 82. The method of claim 81, wherein:  
2 the providing step is carried out with the loop forming an angle of 70-110 degrees  
3 when in the expanded position.

1 83. The method of claim 81, wherein:  
2 the providing step is carried out with the loop having a substantially constant  
3 perimeter size.

1 84. The method of claim 81, wherein:  
2 the providing step is carried out with the loop being coupled to a plurality of  
3 filaments which form the basket.

1 85. The method of claim 81, wherein:  
2 the providing step is carried out with the loop being elongated when collapsed.

1 86. The method of claim 81, wherein:  
2 the providing step is carried out with the loop being deformed into an elongated  
3 oval when in the collapsed position.

1 87. The method of claim 81, wherein:

the providing step is carried out with the loop having first and second ends, the first and second ends being secured to an elongate insertion element.

88. The method of claim 87, wherein:  
the first and second ends of the loop are secured with a wire wrapped around the first and second ends and the insertion element.

89. The method of claim 81, wherein:  
the providing step is carried out with the loop having a size about equal to the size of the vessel.

90. A device for removing an obstruction from a blood vessel comprising:  
a delivery catheter; and  
an obstruction removing device having a loop and a basket coupled to the loop, the loop being movable from a collapsed position to an expanded position, the obstruction removing device having a longitudinal axis, the loop generally lying in a plane which forms an angle of about 0-25 degrees relative to the longitudinal axis when in the collapsed position and about 45-135 degrees when in the expanded position, the obstruction removing device being contained within the delivery catheter.

91. The device of claim 90, wherein:  
the loop forms an angle of 70-110 degrees when in the expanded position.

92. The device of claim 81, wherein:  
the loop has a substantially constant perimeter size.

93. The device of claim 81, wherein:  
the loop is coupled to a plurality of filaments which form the basket.

94. The device of claim 81, wherein:  
the loop is elongated when collapsed.

95. The device of claim 81, wherein:  
the loop is deformed into an elongated oval when in the collapsed position.

1 96. The device of claim 81, wherein:  
2 the loop has first and second ends, the first and second ends being secured to an  
3 elongate insertion element.

1 97. The device of claim 87, wherein:  
2 the first and second ends of the loop are secured to the insertion element with a  
3 wire wrapped around the first and second ends and the insertion element.

1 98. The device of claim 81, wherein:  
2 the loop has a size about equal to the size of a vessel in which the loop will be  
3 deployed.

1 99. A method of removing an obstruction from a blood vessel, comprising the  
2 steps of:

3 providing an obstruction removing device having an elongate obstruction  
4 engaging element, the obstruction engaging element being movable between a collapsed position  
5 and an expanded position, the obstruction engaging element forming at least three loops when  
6 viewed along a longitudinal axis, the loops being positioned at different positions relative to the  
7 longitudinal axis when viewed along the longitudinal axis;

8 maintaining the obstruction engaging element in the collapsed position and  
9 advancing the obstruction engaging element into obstruction;

10 expanding the obstruction engaging element and engaging the obstruction with the  
11 obstruction engaging element;

12 removing the obstruction with the obstruction engaging element.

1 100. The method of claim 99, wherein:  
2 the providing step is carried out with the loops being angularly displaced relative  
3 to one another when viewed along the longitudinal axis.

1 101. The method of claim 99, wherein:  
2 the providing step is carried out with the obstruction engaging element having at  
3 least 8 loops.



1 102. The method of claim 99, wherein:  
2 the providing step is carried out with the obstruction engaging element having 4-  
3 30 loops.

1 103. The method of claim 99, wherein:  
2 the providing step is carried out with the loops being elongated when viewed from  
3 a side, the loops being generally helical and forming an angle of 20-60 degrees.

1 104. A method of forming an obstruction removing device comprising the steps  
2 of:  
3 providing at least two mandrels extending side-by-side;  
4 winding an elongate element around each of the mandrels a number of times to  
5 form a plurality of loops, wherein each of the loops is formed by a winding around at least one of  
6 the mandrels.

1 105. The method of claim 104, wherein:  
2 the providing step is carried out with at least three mandrels.

1 106. The method of claim 104, wherein:  
2 the providing step is carried out with at least four mandrels.

1 107. The method of claim 104, wherein:  
2 the winding step is carried out to form at least 4 loops.

1 108. The method of claim 104, wherein:  
2 the winding step is carried out to form at least 8 loops.

1 109. The method of claim 104, wherein:  
2 the winding step is carried out with the loops having an angle of 20-60 degrees.

1 110. The method of claim 104, wherein:  
2 the providing step is carried out with the mandrels extending substantially parallel  
3 to one another.



the obstruction removing device forming at least one closed loop in the expanded position, the closed loop exerting substantially equal and opposing radial forces when collapsed.

116. A system for removing an obstruction from a blood vessel, comprising:  
a catheter having a lumen;  
an expandable capture element which is contained within the lumen of the catheter, the capture element being slidable within the lumen of the catheter between a collapsed position contained within the lumen and an expanded position in which the capture element is positioned outside the lumen; and  
an obstruction engaging device having a filament, the filament being movable from a collapsed position to an expanded position, the obstruction engaging element passing through the catheter.

117. A method of removing an obstruction from a blood vessel comprising the steps of:  
providing a catheter, an obstruction engaging device and an expandable capture element, the capture element being contained within a lumen of the catheter in a collapsed position, the capture element moving to an expanded position when positioned outside the lumen, the obstruction engaging device having a filament which is movable from a collapsed position to an expanded position;  
introducing the catheter into a blood vessel of a patient;  
engaging an obstruction with the filament;  
expanding the capture element; and  
moving the obstruction into the capture element with the engaging device after the engaging and expanding steps.

118. A system for removing an obstruction from a blood vessel, comprising:  
a catheter having a lumen;  
an expandable capture element contained within the lumen of the catheter, the capture element being in a collapsed position when contained within the lumen and being in an expanded position when positioned outside the lumen, the expandable capture element having a support structure forming a closed loop having a plurality of integrally formed hinges; and

an obstruction engaging device which extends through the expandable capture element, the engaging device having a collapsed shape and an expanded shape.

119. A method of removing an obstruction from a blood vessel, comprising the steps of:

providing a obstruction engaging element having a collapsed position and an expanded position, the obstruction engaging element having at least one filament, the filament being in a substantially straight configuration when collapsed;

advancing the obstruction engaging element through a patient's vascular system to an obstruction with the obstruction engaging element in the collapsed position; and

engaging the obstruction with the obstruction engaging element, the filament engaging the obstruction with a shape which extends from a proximal end toward a distal end, turns back toward the proximal end and again turns back and extends toward the distal end.

120. A device for removing an obstruction from a blood vessel, comprising: a delivery element having a lumen; and

an obstruction engaging element positioned in the lumen, the obstruction engaging element having a filament which has a collapsed position and an expanded position, the filament being in a substantially straight configuration when collapsed within the lumen of the delivery element, the filament being movable to a shape which extends from a proximal end toward a distal end, turns back toward the proximal end and again turns back and extends toward the distal end.

121. A method of removing an obstruction from a blood vessel, comprising the steps of:

providing a obstruction engaging element having a collapsed position and an expanded position, the obstruction engaging element having at least one filament which is coated with fibrin;

advancing the obstruction engaging element through a patient's vascular system to an obstruction with the obstruction engaging element in the collapsed position;

positioning the obstruction engaging element to engage the obstruction; and

removing the obstruction with the obstruction engaging element.